Identification of Cardiac Arrhythmias using ECG

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Abstract—Heart failure is the most common reason of death nowadays, but if the medical help is given directly, the patient’s life may be saved in many cases. Numerous heart diseases can be detected by means of analyzing electrocardiograms (ECG). Artificial Neural Networks (ANN) are computer-based expert systems that have proved to be useful in pattern recognition tasks. ANN can be used in different phases of the decision-making process, from classification to diagnostic procedures. This work concentrates on a review followed by a novel method. The purpose of the review is to assess the evidence of healthcare benefits involving the application of artificial neural networks to the clinical functions of diagnosis, prognosis and survival analysis, in ECG signals. The developed method is based on a compound neural network (CNN), to classify ECGs as normal or carrying an Atrio Ventricular heart Block (AVB). This method uses three different feed forward multilayer neural networks. A single output unit encodes the probability of AVB occurrences. A value between 0 and 0.1 is the desired output for a normal ECG; a value between 0.1 and 1 would infer an occurrence of an AVB. The results show that this compound network has a good performance in detecting AVBs, with a sensitivity of 90.7% and a specificity of 86.05%. The accuracy value is 87.9%.

Keywords—Artificial neural networks, Electrocardiogram, Feature extraction.

I. INTRODUCTION
Cardiovascular diseases are the main cause of death globally, where more people die annually from cardiovascular diseases. The electrocardiogram (ECG) signal is one of the most important tools in clinical practice to assess the cardiac status of patients. This signal represents the potential difference between two points on the body surface, versus time. Extracting the features from this signal has been found very helpful in explaining and identifying various cardiac arrhythmias. This could be difficult, when the size of the data of the ECG is huge and the existence of different noise types may be contained in the ECG signals. Furthermore manual analysis is considered time consuming and is prone to errors; hence arises the importance of automatic recognition of the extraction of the features ECG signals. Many tools and algorithms have been proposed to extract feature from ECG signals such as, total least squares based. Most of the techniques, involve significant amounts of computation and processing time for features extraction and classification. Another disadvantage is the small number of arrhythmias that can be classified to two or three arrhythmias. Therefore, there is a need for a new technique to classify a larger number of arrhythmias. In addition, the proposed technique can be amenable to real time implementation so it can be used in intensive care units or ECG signal collected.
Fig Normal ECG Waveform

II. METHODOLOGY
Fig. 1 depicts the stages of the proposed algorithm for heartbeat classification schema. It consists of three stages: preprocessing stage, feature extraction stage, and classification stage. The ECG signals are first preprocessed to remove baseline wander, power line interference, and high frequency noise. Then, the ECG signal undergoes different process to enhance signal quality, and to omit equipment and environmental effects. The natural resonance complex frequencies are calculated and are used as feature. Finally, various classifier models are employed to test those features and the diagnosis is reached.

II. PREPROCESSING
All ECG data from the MIT-BIH have been filtered to remove the noise that may influence the ECG signal including, baseline wander, artifact, and power line interference. The presence of these noise sources in the signal Butterworth band pass filter is designed to remove these low and high unwanted bands of frequencies. The cutoff frequencies of the band pass filter are selected to lie in the range 0.5 to 40 Hz may mislead the feature extraction and classification.

IV. CLASSIFIER MODELS
A. Artificial Neural Network
Neural network are analytical techniques modeled analogous to the process of learning in the cognitive system and the neurological functions of the brain. They are capable of predicting new observations from previous observations after executing the learning process using the past existing data. Neural networks or artificial neural...
networks (ANNs) can be defined as a computational system consisting of a set of highly interconnected processing elements, called neurons, which process information as a response to external stimuli. Stimuli are transmitted from one processing element to another via synapses or interconnection, which can be excitatory or inhibitory. ANNs are useful in application areas such as pattern recognition, classification, etc. A multilayer feed forward network named the multilayer perceptrons (MLPs) is employed as a class of neural networks. Usually, MLP is made up of several layers of neurons. Each layer is fully connected to the next one. MLP consists of two phases, the training phase and the testing phase. During the training phase, the features are applied at the input and the corresponding desired classes are at the output of MLP classifier. A training algorithm is executed to adjust the weights and the bias until the actual output of the MLP matches the desired output and performance satisfaction is reached. In the test phase, a set of test features, which are not part of training features, are applied to the trained MLP classifier to test the classification of the unknown features.

B. K-Nearest Neighbor

K-Nearest Neighbor (KNN) is based on the principle that the instances within a dataset will generally exist in close proximity to other instances that have similar properties. If the instances are tagged with a classification label, then the value of the label of an unclassified instance can be determined by observing the class of its nearest neighbors. The KNN locates the $K$ nearest instances to the query instance and determines its class by identifying the single most frequent class label.

C. Linear Discriminate Analysis

The aim of linear discriminate analysis (LDA) known as Fisher’s LDA is to use hyper planes to separate the data of the different classes. The separating hyper plane is obtained by seeking the projection that maximizes the distance between-classes and minimizes the distance within-classes. To solve an N-class problem ($N > 2$) several hyper planes are used. This technique has less computational requirements making it suitable for such class of problems. Moreover this classifier is simple to use and generally provides good results in many applications.

D. Support Vector Machines

Support vector machine (SVM) maps the input vectors to a higher dimensional space where a maximal separating hyper plane is constructed. Two parallel hyper planes are constructed on each side of the hyper plane separating the data. The separating hyper plane is the hyper plane that maximizes the distance between the two parallel hyper planes. An assumption is made that the larger the margin between these parallel hyper planes is, the better the impact of the classifier will be. Although SVM were primarily designed for binary classification problems, it can be used in multi-class classification problems. The most common approaches to create $M$-class classifiers, are the “one versus the rest” and the “pair wise classification”. In this paper, “one versus the rest” approach is presented. Detailed information on SVM can be

V. SIMULATION RESULTS

In order to investigate the validity of the proposed method, four classifiers model are employed. Neural networks, K nearest neighbor, linear discriminate analysis and multi-class support vector machine. All classifier models were designed trained and tested using the poles and the accompanied complex resonant frequencies sets extracted from ECG signals. All features sets are divided into independent training and testing
sets using n-fold cross validation method. This scheme randomly divides the available data into n approximately equal size and mutually exclusive folds. For an n-fold cross validation run, the classifiers are trained with a different n fold used each time as the testing set, while the other n-1 folds are used for the training data. In this study three fold cross validation were employed. A feed forward multilayer perceptron (MLP) neural network with three layers is implemented, input layer, hidden layer, and output layer. The number of neurons selected at input layer is equal to the number of poles and the accompanied complex frequencies. The neurons at the output layer are selected according to the number of classes. One step secant back propagations training function is used to update the weight. The Tan-Sigmoid function is used as the transfer function in the first and second layers, and pure line function is used in the output layer. An error-correction rule is used to adjust the synaptic weights; where the error is the difference between the target and actual network output. The distance function applied for K nearest neighbor technique is the Euclidean distance to match the test examples with training examples, and for different values of k, where k is taken to be 1, 3 and 5. One versus the rest MC-SVM technique with linear training algorithm is employed in this work.

VI. IMPLEMENTATION PROCEDURE AND DISCUSSION OF RESULTS
Initially, ECG signals were filtered using a Butterworth band pass filter with cutoff frequencies of 0.5 to 40 Hz to reduce the noise. Figure 2a, shows a normal ECG signal corrupted with baseline drift and power line interference noise. In Figure 2b, shows a noise free ECG signal as a result of applying the Butterworth band pass filter.

VII. SUMMARY
A multirate processing algorithm incorporating is described for ECG beat detection. It can be categorized as a real-time algorithm since it has a minimal beat detection latency. The beat detection accuracy of the algorithm is comparable to other algorithms reported in the literature. The algorithm is computationally efficient since the beat detection logic operates at the subband rate. Further improvements to the algorithm may be easily achieved by using...
more features of the frequency components of the ECG. A FB-based algorithm enables time and frequency-dependent analysis to be performed on the ECG. The FB-based algorithm provides a unified framework for other ECG signal processing tasks such as signal enhancement, noise alert, and arrhythmia classification.

REFERENCES


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